

Study and Susceptibility Status of Bedbug *Cimex hemipterus* (Hemiptera: Cimicidae) in IPB Darmaga Campus Area and Its Surrounding

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ABSTRACT

Bed bugs infestation in the 1970s was considered disappeared, but since 2000s, re-emergence of bed bugs were reported from all over the world. The study of bed bugs infestation was carried in campus area of IPB University, Darmaga and its surrounding from October 2014 to February 2015. The study was aimed to determine bed bugs distribution and the degree of infestations, the biological aspect of bed bugs and their resistance to household insecticides. The bed bugs survey and collection were conducted in two types of residential areas *i.e* housing and temporary shelter. Housing divided into two types *i.e* complexes residential and densely populated, whereas temporary shelter were divided into four types *i.e* dormitories, boarding school, boarding house and guest house. Moreover, resistance of bed bugs were studied against three groups insecticides including organophosphate (malathion 5%), pyrethroid (deltamethrin 0.05%), and carbamate (propoxur 0.1%) by WHO method. The result showed that 64 rooms of the 244 observed rooms in all types of residential were infested by bed bugs. The only bedbug species found was tropical bedbug, *Cimex hemipterus*. The highest infestation found in student dormitory was 25.41%, while lowest was 0.41% and no bedbug infestation was found in other type residential. The mortality of bed bugs against malathion were the highest (87.50%) and the shortest LT50 (0.14 days). Furthermore, the mortality to deltamethrin was 21.43% with LT50 9.12 days, whereas in propoxur showed the lowest mortality (10%) and the longest LT50 (12.88 days). It showed that the bed bugs population in student dormitories in the Darmaga Campus area were resistant to three types of insecticides, especially to propoxur.

Keywords: *bedbug, Cimex hemipterus, IPB Darmaga campus, resistance*

1. INTRODUCTION

The re-emergence of bedbug infestation has received attention from all over the world, especially among professional pest control [1]. Re-emerging of bedbug infestations was reported in the United States [2], Brazil [3], Europe [4], Canada [5], Italy [6,7], Australia [8], South Korea [9], Israel [10], China [11] and Nigeria [12]. In Southeast Asia the problem of bedbug infestation has been reported in Malaysia and Singapore [13], and Thailand [14].

Bed bug infestation in Indonesia until the late 1970s were found in housing, theatre and hotels. One of the incidents of bedbug infestation in Indonesia occurred in 2008 in Bali Province, Indonesia. Two hotels in Denpasar were found to be infested with bed bugs which were probably carried along with clothes on luggage of foreign tourists [15]. The increase of bed bug infestation is unknown, but several factors such as the increase of

domestic and international travel, reduce the use of residual insecticides indoors and insect resistance contribute to the appearance of re-emergence of bed bug infestation [1].

Losses due to bed bugs infestation in the tourism sector have been reported. Pinto *et al.* [16], wrote that the tourism sector in Australia suffered a loss of AUS \$ 100 million per year. According to hotel managers in Australia there was an increase in bed bug infestations by 20%. The infestation of bed bugs caused several hotels to be sued by hotel guests who felt uncomfortable, so many hotels suffered losses [8].

Cases of re-infestation of bed bugs may still occur in residential areas in Indonesia, but have not been widely studied and scientifically reported. The campus area of the IPB University Darmaga has the potential to get bed bug infestation because it is an area inhabited by hundreds and even thousands of students who come and go from various regions each year. This study aimed to determine the

distribution and level of bed bugs infestation in the Darmaga IPB Campus and its surrounding areas, to determine the biological aspects of bed bugs, and to determine its resistance to insecticide. This research was expected to provide the latest data and information, especially about bed bugs infestation in the city of Bogor.

1.1. Materials and Methods

The study was conducted in a community residential area divided into housing and temporary housing in the IPB University Darmaga Campus Bogor and its surrounding areas. The study was conducted from October 2014 - February 2015.

Types of housing were divided into densely populated and complex. Dense population housing was irregular solid housing. The locations were taken in Babakan and Cibanteng villages. Complex was a collection of houses that line up regularly. The location was taken place in the housing area of the Darmaga IPB Campus. The bedbug collection was randomly selected from each type of housing for 20 houses. Meanwhile, bedbug collection at temporary housing was conducted in six student dormitories, one boarding school, two boarding houses and two guest houses that were closest to the campus area of Darmaga IPB. Sampling was 30% each of the available rooms.

1.1.1. Bedbug rearing

Bed bugs were obtained from the field collection at the research site, then kept in Entomology Laboratory in Faculty of Veterinary Medicine, IPB University. Maintenance (rearing) was done according to Tawatsin *et al.* [17] with some modifications. The purpose of this maintenance was to determine the bed bugs biological aspects and obtain a bedbug colony to test its resistance. Temperature and relative humidity in the laboratory were kept at 26-29°C and 60-80%. Bed bugs were kept in 15 mm x 100 mm plastic containers which the top was covered with a filter cloth. About 10 pieces of 4x8 cm paperboard were folded and then put into a plastic container as a hide place to bed bugs. Bed bugs were fed with blood of mice (*Mus musculus*) for two days. Mice were put into a staple cage and then put into a container and left in contact with bed bugs for 15 minutes.

1.1.2. Bedbug preservation and identification

Some adult bed bugs that were obtained from field, then preserved and mounted to be prepared microscope slide by [18] for identification purpose. Then, bedbug identification was used Pratt and Stojanovich's [17] identification key.

1.1.3. Measurement of bedbug resistance

Bedbug resistance test was used WHO protocol No WHO/VBC/82.857 with three kinds of impregnated papers from three classes of insecticide *i.e.* malation 5% (organophosphate), propoxur 0.1% (carbamate) and deltamethrin 0.05% (pyrethroid) [20]. Before testing the adult bed bugs were fed with blood mice for five consecutive days to avoid death from starvation.

Insecticide impregnated paper 3x5 cm lined in the inside wall of glass tube 17x1.6 cm. As a negative control, other glass tubes lined with non-insecticidal paper. Each tube was filled with 10 adult male and female bed bugs. The glass tube was placed upright on a 15x10x9 cm buffer rack placed in a 20 x 20 x 15 cm plastic container covered with a damp cloth to maintain moisture. In insecticidal tubes, the mortality rate of bed bugs for carbamate was carried out after 24 hours of exposure [21], while for organophosphate and pyrethroid groups for 16 hours [20, 21]. Bed bugs that have been in contact with insecticides were transferred into clean glass tubes filled with white paper without insecticides. Then after 24 hours the number of bed bugs that have died were counted and recorded. This test was repeated five times.

1.1.4. Data analysis

1.1.4.1. Measurement of the distribution and degree of bedbug infestation

The distribution of bedbug infestations was expressed as a percentage, while the determination of the degree of infestation was measured based on Hadi and Rusli [22], which was the safe category (-) for no bed bugs, low category (1-5 of nymph and adult bed bugs, with or without eggs), medium (6-10 nymph and adult bed bugs, with or without eggs), high (more than 10 nymph and adult bed bugs, with or without eggs). If there was only bed bug eggs, it was categorized as high infestations.

1.1.4.2. Determine bedbug resistance

The resistance of bed bugs to malation, propoxur, and deltamethrin was expressed by percentage of bedbug mortality. The bedbug mortality between 98-100% was susceptible, and below 98% was resistant [23].

1.2. Our Contribution

This paper contributes in providing basic data on infestation of bedbugs in residential areas, especially in the IPB University Darmaga Campus in a scientific manner. In addition, data related to *C. hemipterus* biology was the first information reported in Indonesia.

1.3. Paper Structure

The rest of the paper is organized as follows. Section 2 described all information obtained both from field observations and measurements of bedbug resistance in the laboratory. Section 3 presented the conclusion.

2. RESULTS AND DISCUSSION

2.1. Species and Morphology of Bedbugs

All bedbug were found in IPB University Darmaga Campus and its vicinities were *Cimex hemipterus*, which is bedbug species that exists in the tropics. The characteristic of this bedbug was by the pronotum with fine hairs around the pronotum (fringe hairs), proboscis length only reached the middle of the first coxa, not to the second coxa, and fourth antenna segment was shorter than the third segment. Fine hair on the pronotum was shorter than the width of the eye. The pronotum portion of *C. hemipterus* was slightly curved as presented in Figure 1, but was not curved inward compared to *C. lectularius*. The pronotum characteristic distinguishes *C. hemipterus* from *C. lectularius* [19]. The average pronotum width and length of *C. hemipterus* were 0.57 mm and 1.10 mm, while *C. lectularius* is 0.66 mm and 1.22 mm [14].

2.2. Distribution and Degree of Bedbugs Infestation

Bed bugs infestation in the IPB Darmaga Campus were commonly found in communal areas, *i.e.* student dormitories, especially in the male dormitory. Based on information from dormitory students, bed bugs had been present in several rooms since the students came. This was due to cotton kapok mattresses and beds used by students have been infested with bed bugs before. Bedbug infestation at mattresses and bed could be seen visually by the presence of nymphs, adults, eggs and black spots on the surface of the mattress upholstery or on the wooden walls of the bed.

This bedbug infestation was very disturbing to the students, and even many student parents have complained about bedbug problem. According to the manager of IPB Dormitory, control means had been carried out in 2014, by replacing all kapok mattresses, pillows and bolsters that were both infested in all dorm rooms. However, it has not been able to completely eliminate bed bug infestation, due to reinfestation.

Bedbug infestation and black patches as a sign of bed bugs were not found on mattresses, chairs and household appliances in residential areas of complexes. Bedbug infestation was not found at the boardingschool and guesthouses. However, they have a risk of bed bugs infestation, considering of occupants who alternated and came from different areas. Observation of bedbug infestations conducted in the area around the IPB

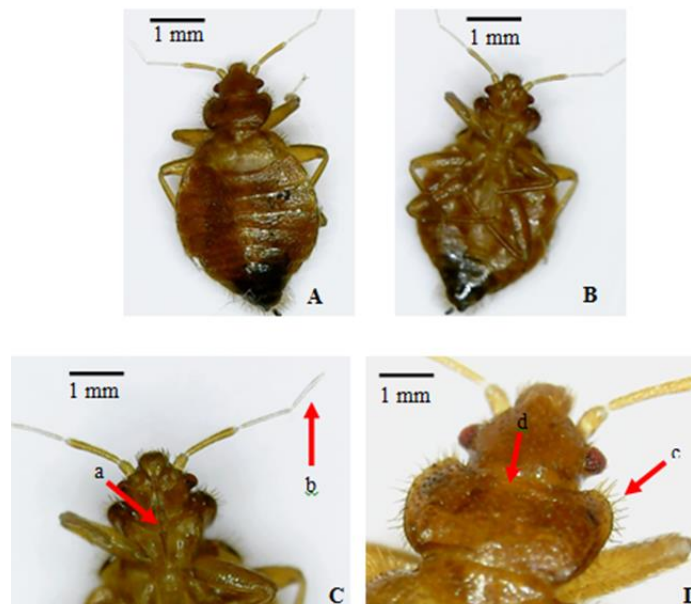


Figure 1 Morphological features of *C. hemipterus*: (a) dorsal of male adult, (b) ventral adult male, (c) ventral head section; (a) proboscis; (b) antenna, (d) dorsal thoracic section; (c) fine hairs shorter than the width of the eye; (d) pronotum slightly curved

Table 1 Distribution and degree of bed bug infestation in various types of regions

Regions		Inspected houses	Inspected rooms	(+) rooms	Average (%)	Infestation degree		
						Low	Medium	High
Residences	Complexes	20	20	0	0	0	0	0
	Densely populated	20	20	1	0.41	0	0	1
Temporary housing	Dormitory	6	175	62	25.41	26	8	28
	Boarding House	2	5	1	0.41	0	0	1
	Boarding school	1	12	0	0	0	0	0
	Guesthouse	2	12	0	0	0	0	0
Total		51	244	64	26.23	26	8	30
(%)						10.65	3.28	12.30

University Darmaga Campus included densely populated housing, boarding houses and boarding schools.

Bedbug infestations in male dormitory were found in piles of foam mattresses (spring beds) that had not been used for a long time, whereas in densely populated residential, bed bugs were found on pillows in the room. No bed bugs infestation was found in the boarding school area.

The total number of rooms that had been inspected from all types of residential areas was 244 rooms, while the number of rooms that had been positively infested by bed bugs were 64 rooms consisting of 62 rooms in student dormitories, one room in boarding houses and one room in densely populated housing. The average room infested with bed bugs was 26.23%.

The highest spread of bed bug infestation was found in student dormitories at 25.41%, then boarding houses and densely populated housing at 0.41%. The degree of bedbug infestation in the dormitories were varied, 26 rooms were low infested (10.65%), 8 rooms were medium (3.28%), while the highest bed bug infestation occurred in 28 rooms. Then, each room in densely populated housing

and boarding house had high bedbug infestation (12.30%) (Table 1).

2.3. Life Cycle of *Cimex hemipterus* in the Laboratory

The life cycle of *C. hemipterus* is hemimetabolous (egg-five instar nymph-adult). The observations in laboratory at a temperature of 26-29 °C and 60-90% relative humidity showed the average time of eggs incubation was 5.67 ± 1.16 days. The average time needed for the first instar nymph to become fifth instar was 49.67 ± 16.64 days, then overall life cycle from eggs to adulthood took 55.33 ± 19.09 days (Table 2). Khan and Rahman [24] showed that about 59.00 ± 5.57 days for *C. hemipterus* to complete one life cycle, whereas according to Suwannayod *et al.* [14] the life cycle of bed bugs is required 39.9 ± 7 days.

Table 2 Average time of development stages of *C. hemipterus* in laboratory (temperature 26 °C ± 3 °C and humidity 60 ± 30%)

Replica- tion	Egg incubation (days)	Nymphal stage (days)					Total nymph- hal stage (days)	Egg - Adult (days)
		1 st	2 nd	3 rd	4 th	5 th		
1	7	6	14	13	8	10	52	59
2	5	8	19	16	9	10	62	67
3	5	8	8	5	8	6	35	40
Average	5.67±1.15	7.33±1.15	13.67±3.46	11.33±7.02	8.33±3.21	8.67±4.16	49.67±16 .64	55.33±19. 09

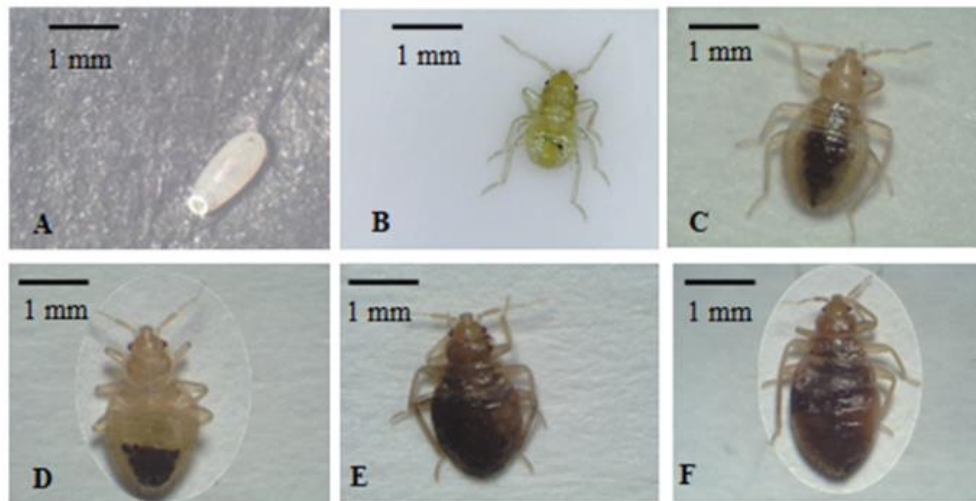


Figure 2 Development Stages of *C. hemipterus*: (a) egg, (b) first nymph, (c) second nymph, (d) third nymph, (e) fourth nymph, (f) fifth nymph

2.4. *Cimex hemipterus* Bedbugs Resistance Against Insecticides

The results of *C. hemipterus* bed bug susceptibility test against three groups of insecticides were presented in Table 3. The average *C. hemipterus* mortality after 24 hours contacted with the three insecticide groups showed less than 98%. Bed bug mortality against malation showed the highest rate (87.50%), while deltamethrin was 21.43%, and lowest mortality rate (10%) in propoxur. This showed that the bed bug population from the student dormitory in the IPB Darmaga Campus had been resistant to these three groups of insecticides.

Bed bug infestation in Indonesia in the period of 1970-2000 was fully controlled because of the use of organochlorine-based insecticides such as dicloro diphenyl trichloroethane (DDT). However, since the occurrence of cases of population resistance of various types of insects including bed bugs against DDT, the use of this type of insecticide was stopped. Organophosphate and carbamate since the 1970s are class of insecticides that are widely marketed for insect control, including in pest control programs for household pests [25]. The bed bug population resistance that occurred in this student dormitory was likely to be related to the used of

insecticides, especially the type of propoxur and deltamethrin commonly used daily by students to control pest insects, especially mosquitoes, flies, ants and cockroaches.

Cases of bed bug resistance in developing countries are widely reported, including in Thailand in 1970, *C. hemipterus* is resistant to DDT insecticide [26]. In Tanzania *C. hemipterus* has been resistant to permethrin and α -sipermetrin [27]. In the Kandy region, Sri Lanka *C. hemipterus* has been resistant to malathion 5%, while in the Nuwara Eliya region, Sri Lanka the bed bug population was resistant to propoxur 0.8% [21]. The *C. lectularius* bed bug in Thailand is also known to have been resistant to bifentrin and α -sipermetrin [14], whereas in Denmark *C. lectularius* is resistant to permethrin and deltamethrin [28].

3. CONCLUSION

The only bed bugs species found in IPB Darmaga Campus and its surrounding area was *Cimex hemipterus*. The highest spread of this bed bug infestation was occurred in student dormitories by 25.41%, then boarding houses and densely populated houses by 0.41%. The average value of bed bug infestation in dormitory was varied from 10.65% of the infested sample rooms, 3.28%

Table 3 Mortality, susceptibility status, LT_{50} , dan LT_{90} of bed bug *C. hemipterus* against three groups of insecticides

Insecticides	Mortality (%)	Susceptibility status	LT_{50} (days)	LT_{90} (days)
Malation 5%	87.50	Resistance	0.14 (0.05 – 0.25)	3.76 (3.02 – 9.00)
Deltametrin 0.05%	21.43	Resistance	9.14 (7.66 - 11.22)	18.42 (15.30 – 24.12)
Propoxsur 0.1%	10.00	Resistance	12.88 (11.55 – 14.45)	21.78 (19.39 – 25.43)

rooms were infested in medium level, while the highest category of bed bug infestation occurred 11.48% of dormitory rooms, one room in densely populated house and the other was boarding house (12.30%).

Development of nymphae stage of *C. hemipterus* at 26-29 °C and 60-90% relative humidity from the first to fifth instar was 49.67 ± 16.64 days. The overall life cycle of bed bugs from eggs to adulthood takes an average of 55.33 ± 19.09 days. Bed bugs from the IPB Darmaga Campus were resistant to all three types of insecticides, especially propoxur.

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REFERENCES

- [1] M.F. Potter, A bed bug state of mind: emerging issues in bed bug management, *Pest Control Technol*, 33 (2005) 82-97
- [2] L. Krueger, Don't get bitten by the resurgence of bed bugs, *Pest Control*, 68 (2000) 58-64
- [3] P.R. Criado, W.B. Junior R.F.J. Criado, R.V. Silva, and C. Vasconcellos, Bed bugs (Cimicidae infestation): the worldwide renaissance of an old partner of human kind, *Braz J Infect Dis*, 15(1) (2011) 74-80
- [4] M.V. Fuentes, S.S. Elipe, S.S. Duran, and M.T.G. Puchades. Bedbug infestations acquired whilst travelling in the European Union, *Rev Ibero-Latinoam Parasitol*, 69(2) (2010) 204-209
- [5] T. Myles B. Brown, B Bedard, R. Bhooi, K. Bruyere, A.L. Chua, M. Macsai, R. Menezes, A. Salwan, and M. Takahashi, Bed bugs in Toronto. Centre for Urban and Community Studies, *Res Bull*, 19 (2003) 1-4 ISSN 0-7727-1429-0
- [6] M. Maseti and F. Bruschi, Bed bug infestations recorded in Central Italy, *Parasitol Int*, 56 (2007), 81-83
- [7] F. Giorda, L. Guardone, M. Mancini, A. Accorsi, F. Macchioni and W. Mignone, Cases of bed bug (*Cimex lectularius*) infestations in Northwest Italy *Vet Italiana* 49(4) (2013), 335-340 .DOI :10.12834/VetIt.1306.03
- [8] S.L. Doggett, M.J. Geary, and R.C. Russell. The resurgence of bed bugs in Australia with notes on their ecology and control, *Environ. Health*. 4(2) (2004) 30-38
- [9] I.Y. Lee, H. An. S.J. Ree, J.A. Linton and T.S. Yong. Reemergence of the bedbug *Cimex lectularius* in Seoul Korea, *Kor. J. Parasitol*. 46(4) (2008) 269-271. DOI:<https://doi.org/10.3347/kjp.2008.46.4.269>
- [10] K.Y. Mum cuoglu. A case of imported bedbug (*Cimex lectularius*) infestation in Israel, *IMAJ*, 10 (2008) 388-389
- [11] C. Wang, X. Wen. Bed bug infestations and control practices in China: implications for fighting the global bed bug resurgence, *J Insect*, 2 (2011) 83-89 .DOI: <https://doi.org/10.3390/insects2020083>. ISSN 2075-4450.
- [12] O.I. Emmanuel, A. Cyprian, and O.E. Agbo. A survey of bedbug (*Cimex lectularius*) infestation in some home and hostel in Gboko Benue State, Nigeria. *Hindawi Publishing Corp Psyche*. (2014) Article ID 762704. DOI:<https://doi.org/10.1155/2014/762704>
- [13] Y.F. How, and C.Y. Lee. Fecundity, nymphal development and longevity of field collected tropical bed bugs *Cimex hemipterus* *Med Vet Entomol*. 24 (2010) 108-116. DOI:<https://doi.org/10.1111/j.1365.2010.00852.x>
- [14] S. Suwannayod, Y. Chanbang and Buranapanichpan. The life cycle and effectiveness of insecticides against the bed bugs of Thailand Southeast, *Asian J Trop Med Public Health*. 41(3) (2010) 548-554
- [15] Anonymous. Pariwisata Bali perlu waspada disinyalir dua hotel besar dimasuki kutu busuk *Bali Post Kolom Ekonomi*, (2008) 129:61 (16-029)
- [16] L.J. Pinto, R. Cooper, and S.K. Kraft, *Bed Bug Handbook: The complete guide to bed bugs and their control*, (2007) (Mechanicsville Maryland: Pinto and Associates Inc)
- [17] A. Tawatsin, U. Thavara, J. Chompoonsri, et al. Insecticide resistance in bed bugs in Thailand and laboratory evaluation of insecticides for the control of *Cimex hemipterus* and *Cimex lectularius* (Hemiptera:Cimicidae) *J Med Entomol*. 48(5) (2011) 1023-1030. DOI:10.1603/MEI1003.
- [18] U.K. Hadi and S. Soviana, *Ektoparasit Pengenalan, Identifikasi dan Pengendalian* (2010) (Bogor: IPB Pr)
- [19] H.D. Pratt and C.J. Stojanovich, Bugs: pictorial key to some species that may bite man. In

- Pictorial Keys to Arthropods, Reptiles, Birds and Mammals of Public Health Significance, (1967)
US Department of Health Education and Welfare
Atlanta GA. p 94
- [20] [WHO] World Health Organization, Bed bugs (unpublished document WHO/VBC/82.857), (1982) pp. 1-9
- [21] S.H.P.P. Karunaratne, B.T. Damayanthi, M.H.J. Fareena, V. Imbuldeniya and J. Hemingway, Insecticide resistance in the tropical bedbug *Cimex hemipterus*, *Pestic Biochem Physiol.* 88 (2006) 102-107. DOI: <https://doi.org/10.1016/j.pestbp.2006.09.006>
- [22] U.K. Hadi and V.T. Rusli, Infestasi caplak anjing *Rhipicephalus sanguineus* (Parasitiformes: Ixodidae) di Kota Bogor, *J Med Vet Indonesia.* 10(2) (2006) 55-60
- [23] [WHO] World Health Organization, Malathion S-1,2-bis (ethoxycarbonyl) ethyl O,O-dimethyl phosphorodithioate, WHO Specification and Evaluation for Public Health Pesticides, (2013) (Geneva: WHO press)
- [24] H.R. Khan and M.D.M. Rahman, Morphology and Biology of the bedbug *Cimex hemipterus* (Hemiptera: Cimicidae) in the Laboratory, Dhaka. *Univ. J. Biol. Sci.* 21(2) (2012) 125-130
- [25] I. Ahmad, Fakta tentang kutu busuk (bed bugs) *Cimex hemipterus* (Hemiptera: Cimicidae) dan cara pengendaliannya, (Bandung: Institut Teknologi Bandung), 2004
- [26] [WHO] World Health Organization, Report WHO Expert Committee on resistance of vectors and reservoirs of disease to pesticides, *Wld Hlth Org Techn. Rep Ser.* (1976) 585
- [27] J. Myamba, C.A. Maxwell, A. Asidi and C.F. Curtis, Pyrethroid resistance in tropical bed bugs *Cimex hemipterus* associated with use of treated bednets, *Med Vet Entomol.* 16 (2002) 448-451
- [28] O. Kilpinen, K.V. Jensen and M. Kristensen, Bed bug problems in Denmark with a European perspective, (2008) p 395-399, *Proceedings 6th International Conference on Urban Pest* 13-16 July Budapest (Hungary: OOK-Press)